

1 Hydrated aluminium sulfate,  $Al_2(SO_4)_3 \cdot xH_2O$ , and chlorine,  $Cl_2$ , are used in water treatment.

(a) A student attempts to prepare hydrated aluminium sulfate by the following method.

- The student heats dilute sulfuric acid with an excess of solid aluminium oxide.
- The student filters off the excess aluminium oxide to obtain a colourless solution of  $Al_2(SO_4)_3$ .

(i) State the formulae of the two **main** ions present in the solution of  $Al_2(SO_4)_3$ .

..... and ..... [2]

(ii) Write an equation for the reaction of aluminium oxide,  $Al_2O_3$ , with sulfuric acid.

Include state symbols.

..... [2]

(iii) What does ' $xH_2O$ ' represent in the formula  $Al_2(SO_4)_3 \cdot xH_2O$ ?

.....  
..... [1]

(iv) The student heats 12.606 g of  $Al_2(SO_4)_3 \cdot xH_2O$  crystals to constant mass.

The anhydrous aluminium sulfate formed has a mass of 6.846 g.

Use the student's results to calculate the value of  $x$ .

The molar mass of  $Al_2(SO_4)_3 = 342.3 \text{ g mol}^{-1}$ .

$x =$  ..... [3]

**(b)** A student tests chlorine gas with damp blue litmus paper. The litmus paper first turns a red colour and is then bleached. A reaction takes place between chlorine and water in the damp litmus paper.

**(i)** Write the equation for the reaction between chlorine and water.

Explain why the damp litmus paper turns a red colour as a result of this reaction.

.....  
.....  
..... **[2]**

**(ii)** Bleach is made by reacting chlorine with cold dilute aqueous sodium hydroxide.

Suggest the formula of the **ion** responsible for bleaching.

..... **[1]**

**[Total: 11]**

- 2 Sulfur, atomic number 16, is found within the Earth's crust. Sulfur is released into the atmosphere at times of volcanic activity.

A sample of sulfur from a volcano was analysed to give the following composition of isotopes.

isotope	abundance (%)
$^{32}\text{S}$	95.0
$^{33}\text{S}$	0.76
$^{34}\text{S}$	4.22

- (a) Define the term *relative atomic mass*.

.....

.....

.....

..... [3]

- (b) Calculate the relative atomic mass of the sample of sulfur.

Give your answer to **two** decimal places.

answer = ..... [2]

- (c) John Dalton, an early 19th century scientist, believed that elements were made up of tiny particles called atoms which could not be divided. Nowadays, chemists know of the existence of sub-atomic particles in atoms and in ions.

Complete the table to show the number of sub-atomic particles in the  $^{33}\text{S}$  atom and  $^{34}\text{S}^{2-}$  ion.

	protons	neutrons	electrons
$^{33}\text{S}$			
$^{34}\text{S}^{2-}$			

[2]

(d) Solid sulfur exists as a lattice of  $S_8$  molecules. Each  $S_8$  molecule is a ring of eight atoms.

How many atoms of sulfur are there in 0.0120 mol of  $S_8$  molecules?

answer = ..... atoms [2]

(e) The only intermolecular forces in solid sulfur are van der Waals'.

(i) Describe how van der Waals' forces arise.

.....  
.....  
.....  
.....  
.....  
.....  
..... [3]

(ii) Suggest why there are **no** other intermolecular forces in solid sulfur.

.....  
.....  
..... [1]

(f) Sodium thiosulfate is a compound of sulfur used to develop photographs.

Hydrated sodium thiosulfate has the formula  $Na_2S_2O_3 \cdot 5H_2O$ .

What is the oxidation number of sulfur in  $Na_2S_2O_3 \cdot 5H_2O$ ?

..... [1]

(g) A student heats 12.41 g of hydrated sodium thiosulfate,  $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$ , to remove the water of crystallisation. A white powder called anhydrous sodium thiosulfate forms.

(i) What does the term *anhydrous* mean?

.....  
..... [1]

(ii) What is the relative formula mass of  $\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$ ?

..... [1]

(iii) Calculate the expected mass of anhydrous sodium thiosulfate that forms.

mass = ..... g [2]

(h) Sulfur hexafluoride,  $\text{SF}_6$ , exists as non-polar covalent molecules with an octahedral shape.

(i) Explain why a molecule of  $\text{SF}_6$  has an octahedral shape.

.....  
.....  
.....  
..... [2]

(ii) Fluorine has a higher electronegativity than sulfur, yet  $\text{SF}_6$  molecules are non-polar.

Explain what is meant by the term *electronegativity* and suggest why  $\text{SF}_6$  molecules are non-polar.

.....  
.....  
.....  
..... [3]

[Total: 23]

3 This question is about a model of the structure of the atom.

(a) A model used by chemists includes the relative charges, the relative masses and the distribution of the sub-atomic particles making up the atom.

Complete the table below.

particle	relative charge	relative mass	position within the atom
proton			
neutron			
electron		1/2000	shell

[1]

(b) Early studies of ionisation energies helped scientists to develop a model for the electron structure of the atom.

Define the term *first ionisation energy*.

.....

.....

.....

.....

.....

.....

[3]

(c) A modern model of the atom arranges electrons into orbitals, sub-shells and shells.

Complete the following table showing the maximum number of electrons which can be found within each region.

region	number of electrons
a 2p orbital	
the 3s sub-shell	
the 4th shell	

[3]



- 4 Magnesium is the eighth most abundant element in the Earth's crust and many rocks are a source of magnesium compounds.

Magnesium carbonate,  $\text{MgCO}_3$ , is present in dolomite, a rock found in the Dolomite mountains in Italy.

A student collected two equal-sized samples of dolomite. These samples were put into two labelled test-tubes, **A** and **B**. Tube **A** was heated until there was no further change in mass and was then allowed to cool. Tube **B** was left unheated.

- (a) Write the equation for the action of heat on the magnesium carbonate present in tube **A**.

..... [1]

- (b) The student wanted to make magnesium chloride crystals. The student added an excess of warm dilute hydrochloric acid to tube **A** and to tube **B**.

- (i) Write the equation for the reaction of magnesium carbonate in tube **B** with dilute hydrochloric acid.

Include state symbols.

..... [2]

- (ii) State **one** similarity and **one** difference the student would see between the reactions in the two tubes.

similarity .....

.....

difference .....

..... [2]

- (iii) From the solution in each tube, the student obtained crystals with the formula  $\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$ .

Calculate the relative formula mass of  $\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$ .

Give your answer to **one** decimal place.

relative formula mass = ..... [1]



(iv) Draw a 'dot-and-cross' diagram to show the bonding in  $\text{MgCl}_2$ .

Show **outer** electrons only.

[2]

(c) A compound containing magnesium, silicon and oxygen is also present in rock types in Italy. A sample of this compound weighing 5.27g was found to have the following composition by mass:

Mg, 1.82g; Si, 1.05g; O, 2.40g.

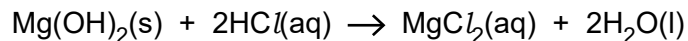
Calculate the empirical formula of the compound.

Show your working.

empirical formula = ..... [2]

**(d)** Pharmacists sell tablets containing magnesium hydroxide,  $\text{Mg}(\text{OH})_2$ , to combat indigestion.

A student carried out an investigation to find the percentage by mass of  $\text{Mg}(\text{OH})_2$  in an indigestion tablet. The student reacted the tablet with dilute hydrochloric acid.



The student found that  $32.00 \text{ cm}^3$  of  $0.500 \text{ mol dm}^{-3}$   $\text{HCl}$  was needed to react with the  $\text{Mg}(\text{OH})_2$  in a 500 mg tablet. [1 g = 1000 mg].

**(i)** Calculate the amount, in mol, of  $\text{HCl}$  used.

amount = ..... mol **[1]**

**(ii)** Determine the amount, in mol, of  $\text{Mg}(\text{OH})_2$  present in the tablet.

amount = ..... mol **[1]**

**(iii)** Determine the percentage by mass of  $\text{Mg}(\text{OH})_2$  present in the tablet.

answer = ..... % **[3]**

**[Total: 15]**

5 Tin mining was common practice on Dartmoor in pre-Roman times. Most of the tin extracted was mixed with copper to produce bronze.

(a) The table below shows the sub-atomic particles of an isotope of tin.

isotope	protons	neutrons	electrons
$^{118}\text{Sn}$			

(i) Complete the table. [1]

(ii) In terms of sub-atomic particles, how would atoms of  $^{120}\text{Sn}$  differ from atoms of  $^{118}\text{Sn}$ ?

.....  
 ..... [1]

(b) The relative atomic mass of tin is 118.7.

Define the term *relative atomic mass*.

.....  
 .....  
 .....  
 ..... [3]

(c) A bronze-age shield found on Dartmoor contained 2.08 kg of tin.

Calculate the number of tin atoms in this bronze shield.  
 Give your answer to **three** significant figures.

answer = ..... [2]

- (d) Tin ore, known as cassiterite, contains an oxide of tin. This oxide contains 78.8% tin by mass. Calculate the empirical formula of this oxide. You must show your working.

answer = ..... [2]

[Total: 9]